

# System Antenna Coverage



The ACTS multibeam antenna system provides electronically controlled high-gain spot beams and is a key technology to be validated as part of the ACTS flight system. The multibeam antenna system consists of separate transmitting and receiving offset Cassegrain antennas, each with a dual, gridded subreflector in a piggyback configuration. The 30-GHz receiving antenna is 2.2 m in diameter; the 20-GHz transmitting antenna is 3.3 m in diameter. The antenna diameters are scaled so that the gains and spot beam sizes are the same for both uplink and downlink beams. The expected nominal ranges of gain-to-noise-temperature ratio and effective isotropic radiated power are given in table I. The transmitting antenna's main reflector is equipped with a two-axis drive that allows vernier

TABLE I.—SUMMARY OF ACTS LINK BUDGET  
[Values subject to change as design is stabilized.]

Beam	Receiving polarization <sup>a</sup>	Receiving	Transmitting	Spacecraft effective isotropic radiated power, dB	Spacecraft gain-to-noise-temperature ratio, dB/K	
		Gain (at edge of coverage) <sup>b</sup> , dB				
East family						
East scan sector	Horizontal	47.7	46.8	59.6	17.0	
Houston		50.8	50.6	62.9	19.2	
Kansas City		50.8	50.7	63.0	19.4	
Los Angeles-San Diego		49.2	48.1	60.4	17.1	
Miami		50.6	50.2	62.6	18.9	
Nashville-Huntsville		50.9	50.8	63.0	20.0	
Seattle-Portland		49.1	48.3	60.6	17.0	
West family						
West scan sector	Vertical	46.1	47.1	59.4	16.0	
Dallas		49.2	50.6	62.6	18.0	
Denver		48.9	50.2	62.3	17.7	
Memphis		49.5	50.9	63.0	18.1	
New Orleans		49.3	50.8	63.0	18.1	
Phoenix		48.5	48.8	61.0	17.5	
San Francisco		48.1	46.1	57.9	16.8	
White Sands		48.9	49.8	62.1	17.7	
Steerable		----	----	55.6	----	
Stationary beams						
Cleveland	Horizontal	50.5	51.3	57.8/64.0	20.1	
Atlanta	Vertical	50.0	51.4	57.8/64.0	19.5	
Tampa	Vertical	50.0	51.0	57.4/63.7	19.8	

<sup>a</sup>Transmitting polarization is orthogonal to receiving polarization.

<sup>b</sup>Edge of coverage for spot beams is defined as 0.27° beamwidth and is nominally 2 dB less than peak gain.

<sup>c</sup>Minimum scan sector gain.

<sup>d</sup>Ratio of low-power to high-power modes.

adjustments of the boresight to align it with the receiving antenna. The front subreflector is gridded to pass one sense of polarization and reflect the orthogonal polarization. The back subreflector is solid and reflects the polarization transmitted by the front subreflector. The focal axes of the two subreflectors are tilted with respect to the main reflector's plane of symmetry so that the two orthogonally polarized feed assemblies (east family and west family) can be placed side by side without mechanical interference. Compact, conical, multiflare horns formed by three flared waveguide sections are used for the fixed and isolated spot horns. To meet the stringent spacecraft pointing requirements ( $0.025^\circ$ ), the receiving antenna will have a monopulse tracking capability associated with the Cleveland fixed beam.

ACTS will employ two hopping spot beam families and three fixed beams for both transmitted and received signals (fig. 8). The beams will provide the coverage shown in figure 8. The hopping beams will be programmed to visit only those areas with traffic for any given experiment scenario. The hopping beams, designed primarily for the baseband processor operating mode, consist of two independent uplink and downlink beams (four beams total) providing simultaneous coverage at the same frequency. The half-power beamwidth of these spot beams is approximately  $0.33^\circ$ , covering roughly a 135-mile diameter. One uplink-downlink beam combination covers the east hopping beam family and the other covers the west hopping beam family. The east family consists of (1) an east scan sector—contiguous areas in the eastern portion of the United States and (2) six isolated spots covering Miami, Nashville-Huntsville, Houston, Kansas City, Seattle-Portland, and Los Angeles-San Diego. The west family

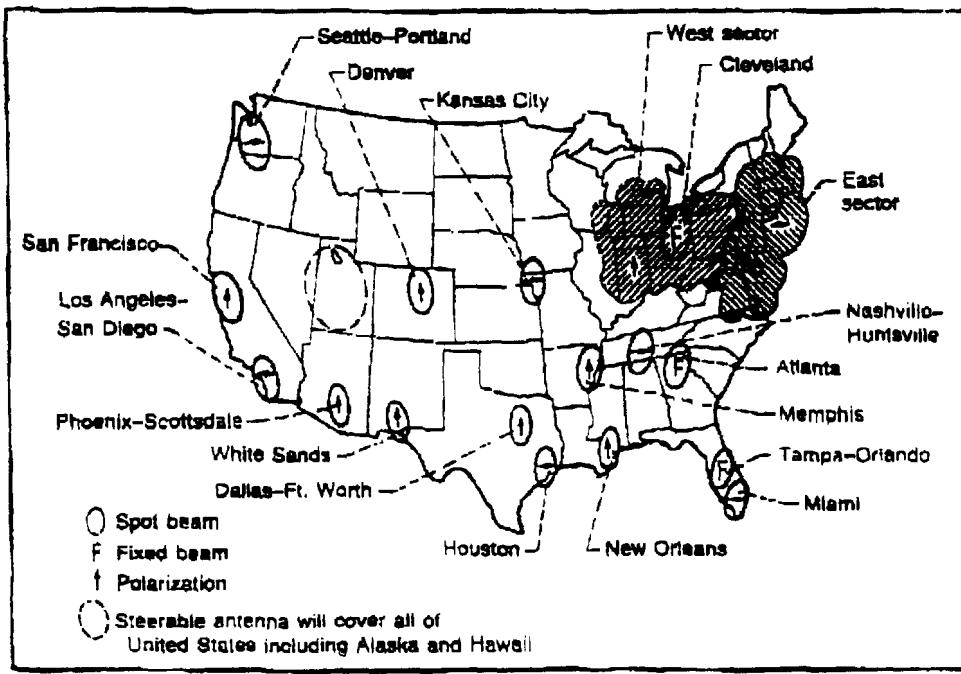


Figure 8.—ACTS multibeam antenna coverage. (ACTS at  $100^\circ$  west longitude.)

## ACTS Parameters

### Frequency Bands

Uplink 29.0 - 29.9 GHz

Downlink 19.2 - 20.1 GHz

Downlink Beacons at 27.505, 20.185, and 20.196 GHz

Uplink Beacon at 29.975 GHz

### Antenna size

Low burst rate terminals LBR-2: 1.2 m and 2.4 m

NASA Ground Station NGS in Cleveland: 5 m

High burst rate terminals HBR: 4 - 5 m

### Transmission Rates and Bandwidth

#### LBR-1:

Uplink 110.592 Msps with no coding (55.29 Msps with rate 1/2 coding)  
165.88 MHz carrier Bandwidth, center frequency at 29.236 GHz

Downlink 110.592 Msps  
165.88 MHz bandwidth, center frequency at 19.44 GHz

#### LBR-2:

Uplink 27.648 Msps with no coding (13.3 Msps with rate 1/2 coding)  
41.472 MHz carrier bandwidth, center frequencies at 29.291 and 29.236 GHz

Downlink 110.592 Msps  
165.88 MHz bandwidth, center frequency at 19.44 GHz

#### HBR:

Uplink 500 Msps, 750.0 MHz carrier Bandwidth, center frequency at 29.420 GHz  
221.18 Msps, 331.77 MHz Bandwidth, center frequencies at 29.160 and 29.680 GHz

Downlink 500 Msps, 750.0 MHz carrier Bandwidth, center frequency at 19.70 GHz  
221.18 Msps, 331.77 MHz Bandwidth, center frequencies at 19.440 and 19.960 GHz

### EIRP

LBR-2 1.2 m: ~ 60 dBW

LBR-2 2.4 m: ~66 dBW

HBR: ~75 dBW

### Elevation Angles

Satellite @ 100 deg West

New York: 35.9 deg.

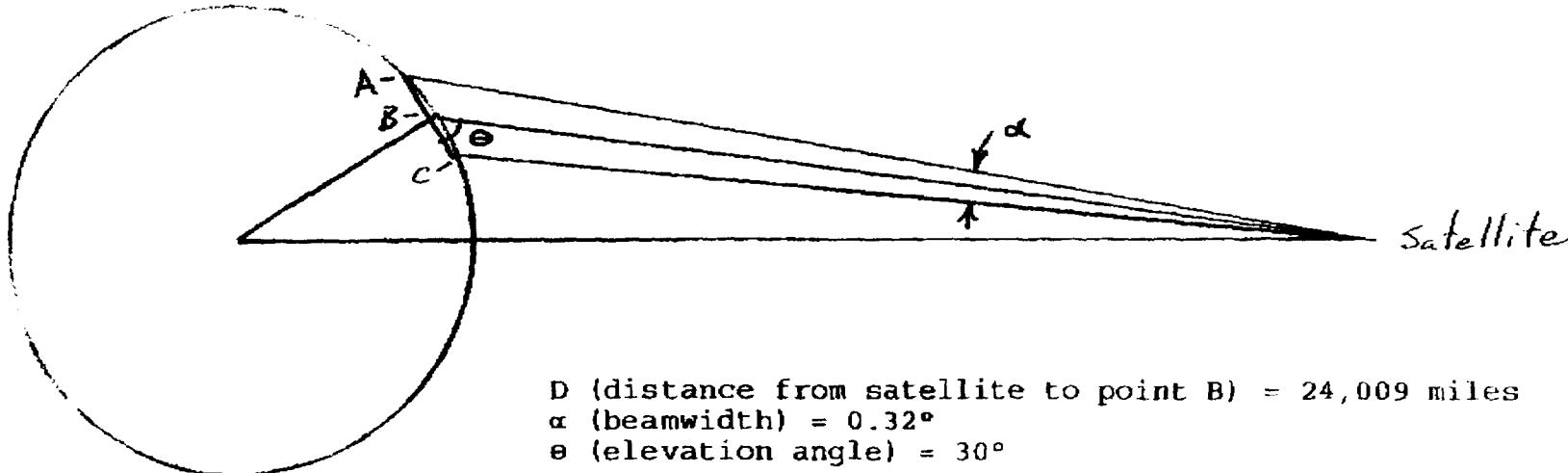
Seattle: 31.2 deg.

Los Angeles: 45.8 deg.

Miami: 52.6 deg.

### Coverage & Satellite EIRP

See attached



D (distance from satellite to point B) = 24,009 miles  
 $\alpha$  (beamwidth) =  $0.32^\circ$   
 $\theta$  (elevation angle) =  $30^\circ$

Assume that footprint of the beam will be an ellipse.  
 $AC$  is the long axis of the ellipse. We can also assume that  $AB \approx BC$

In  $\triangle ABS$   $\angle ASB = 0.16^\circ$

$\angle ABS = 180^\circ - \theta = 150^\circ$  then,

$\angle SAB = 180^\circ - 150^\circ - 0.16^\circ = 29.84^\circ$

Now using sinuses theorem we will have  $\frac{\sin 0.16^\circ}{AB} = \frac{\sin 29.84^\circ}{D}$ ,

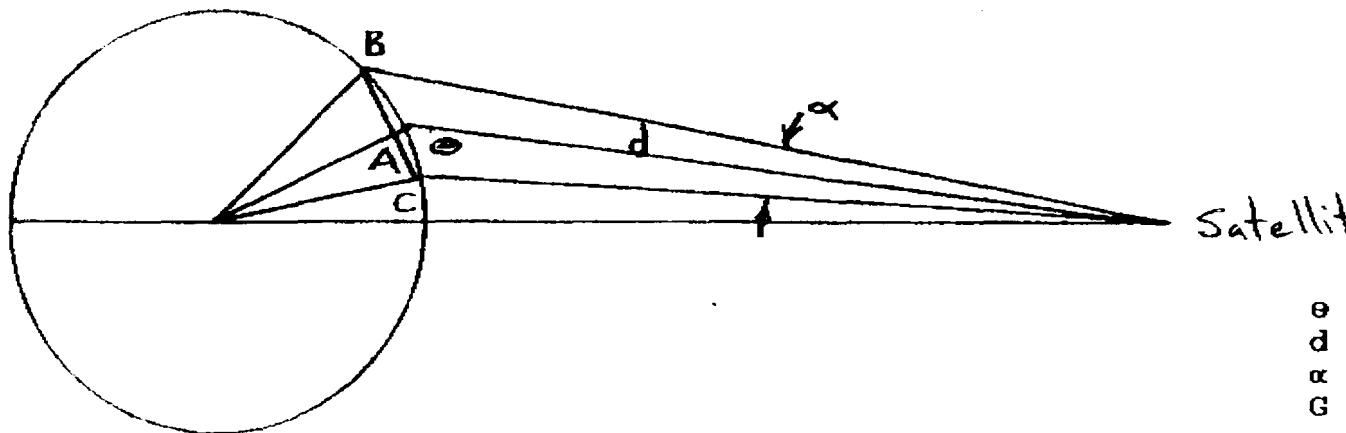
$$\text{Then } AB = D \frac{\sin 0.16^\circ}{\sin 29.84^\circ} = 24,009 \text{ mi.} \times \frac{2.793.10'}{0.4976} \approx 135 \text{ mi.}$$

The short axis of the ellipse will be equal  $D \operatorname{tg} \frac{x}{2} \approx 67 \text{ mi.}$

So area of footprint  $S = ab = 3.14 \times 135 \text{ mi.} \times 67 \text{ mi.} \approx 28,415 \text{ mi.}^2$  (a,b axis of ellipse)

Distance	D	Elevation Angle $\theta$	Gain G	Beamwidth x	Footprint Area
24,009 mi.		$30^\circ$	53 dB	$0.32^\circ$	$28,415 \text{ mi.}^2$
1,500 mi.		$30^\circ$	28 dB	$7^\circ$	$26,015 \text{ mi.}^2$
1,500 mi.		$10^\circ$	28 dB	$7^\circ$	* $56,360 \text{ mi.}^2$

\* Calculations for that area used more accurate calculations



$\theta$        $30^\circ$   
 $d$       24,009 miles  
 $\alpha$        $4.2^\circ$   
 $G$       32 dB

$$\angle BSA = \frac{\alpha}{2} = 2.1^\circ$$

$$\angle BAS = 180^\circ - \theta = 150^\circ$$

$$\angle ABS = 180^\circ - 150^\circ - 2.1^\circ = 27.9^\circ$$

$$\angle ACS = 180^\circ - \theta - 4.1^\circ = 147.9^\circ$$

$$\text{In } \triangle BAS \text{ we have } \frac{BS}{\sin \angle BAS} = \frac{d}{\sin \angle ABS} \times \frac{BS}{\sin 150^\circ} = \frac{d}{\sin 27.9^\circ}$$

$$BS = 25,655 \text{ miles}$$

$$\text{In } \triangle BCS \quad \frac{\sin \alpha}{BC} = \frac{\sin \angle BCS}{BS} \Rightarrow$$

$$BC = BS \frac{\sin \alpha}{\sin 147.9^\circ} = 25,655 \times \frac{\sin 4.2^\circ}{\sin 147.9^\circ} \approx 3,536 \text{ miles}$$

Assume that footprint is an ellipse

$$a = \frac{BC}{2} = 1,768 \text{ miles}$$

$$b = D \operatorname{tg} \frac{\alpha}{2} = 880 \text{ miles}$$

$$S = \pi ab = 4,889,870 \text{ miles}^2, \text{ so it will cover U.S.}$$

FIGURE A  
TRANSMITTER ANTENNA GAIN PATTERNS

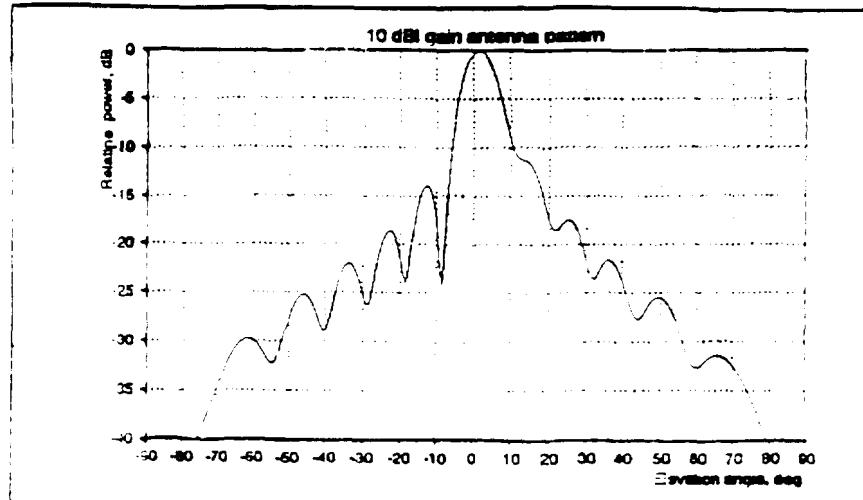
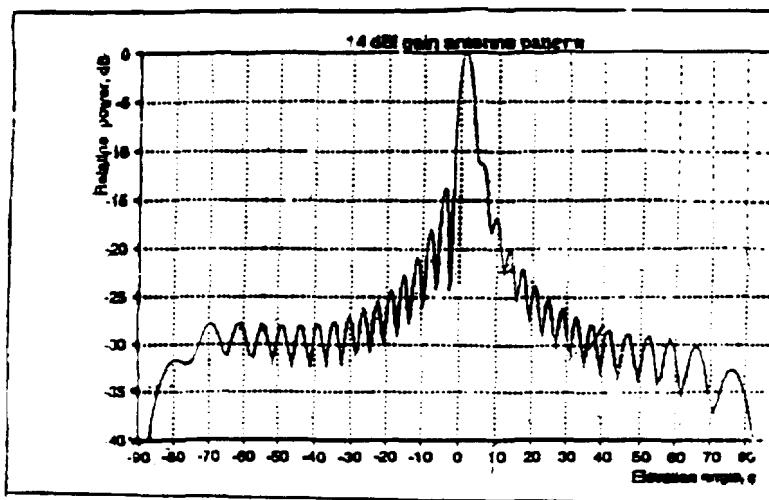
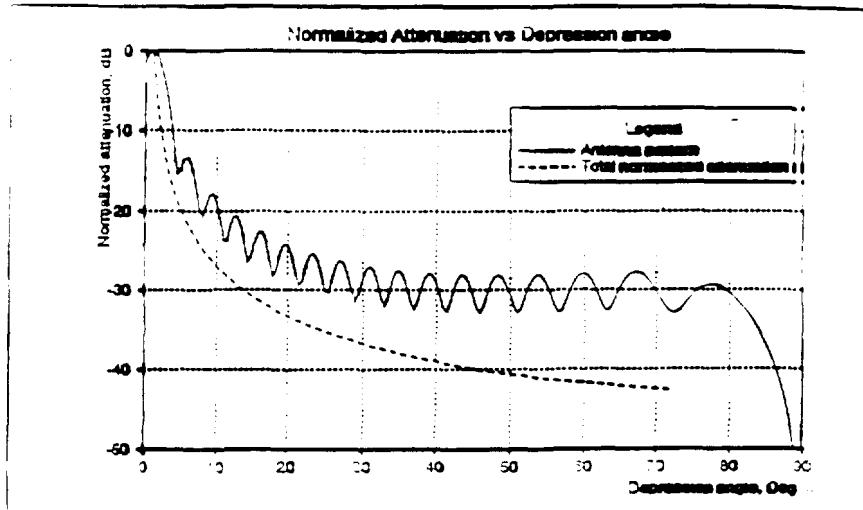
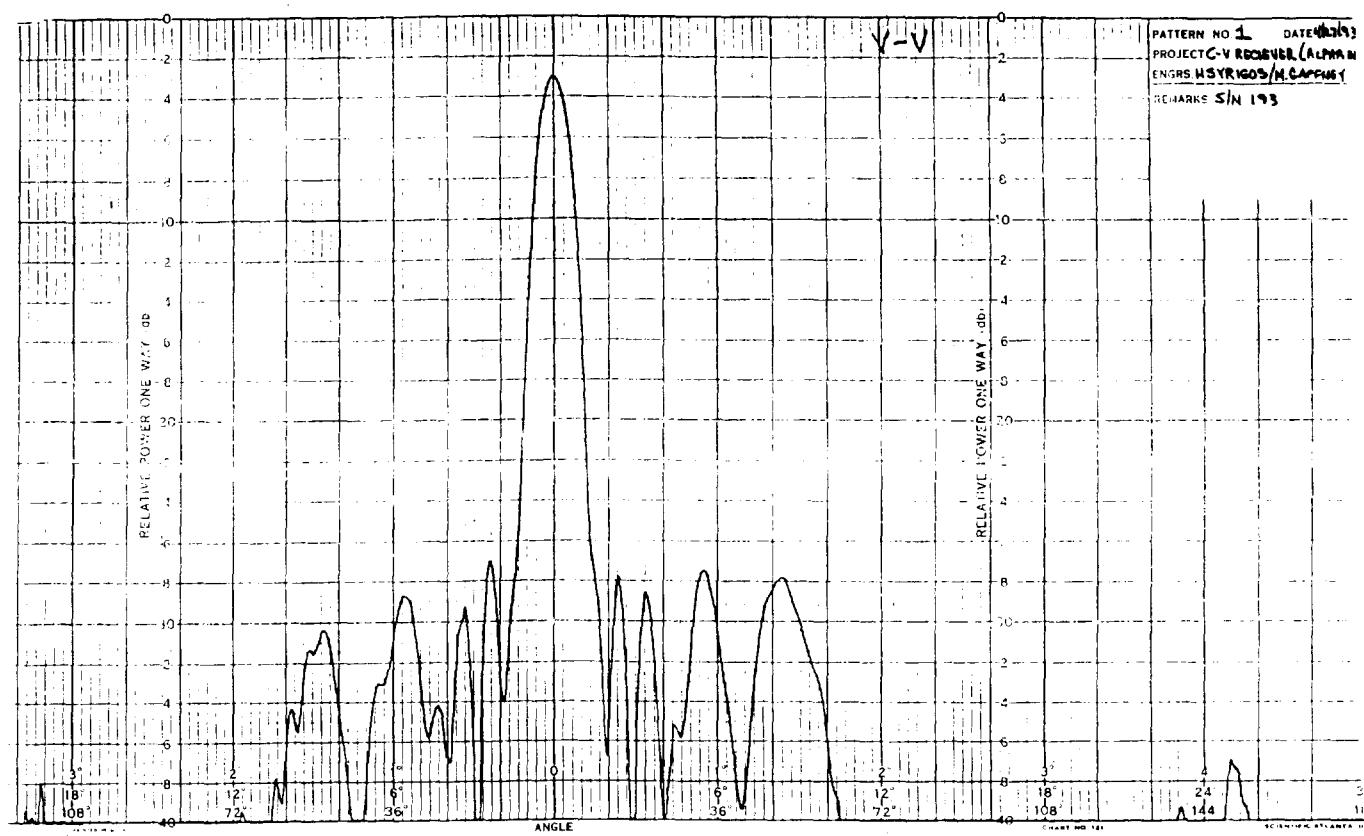
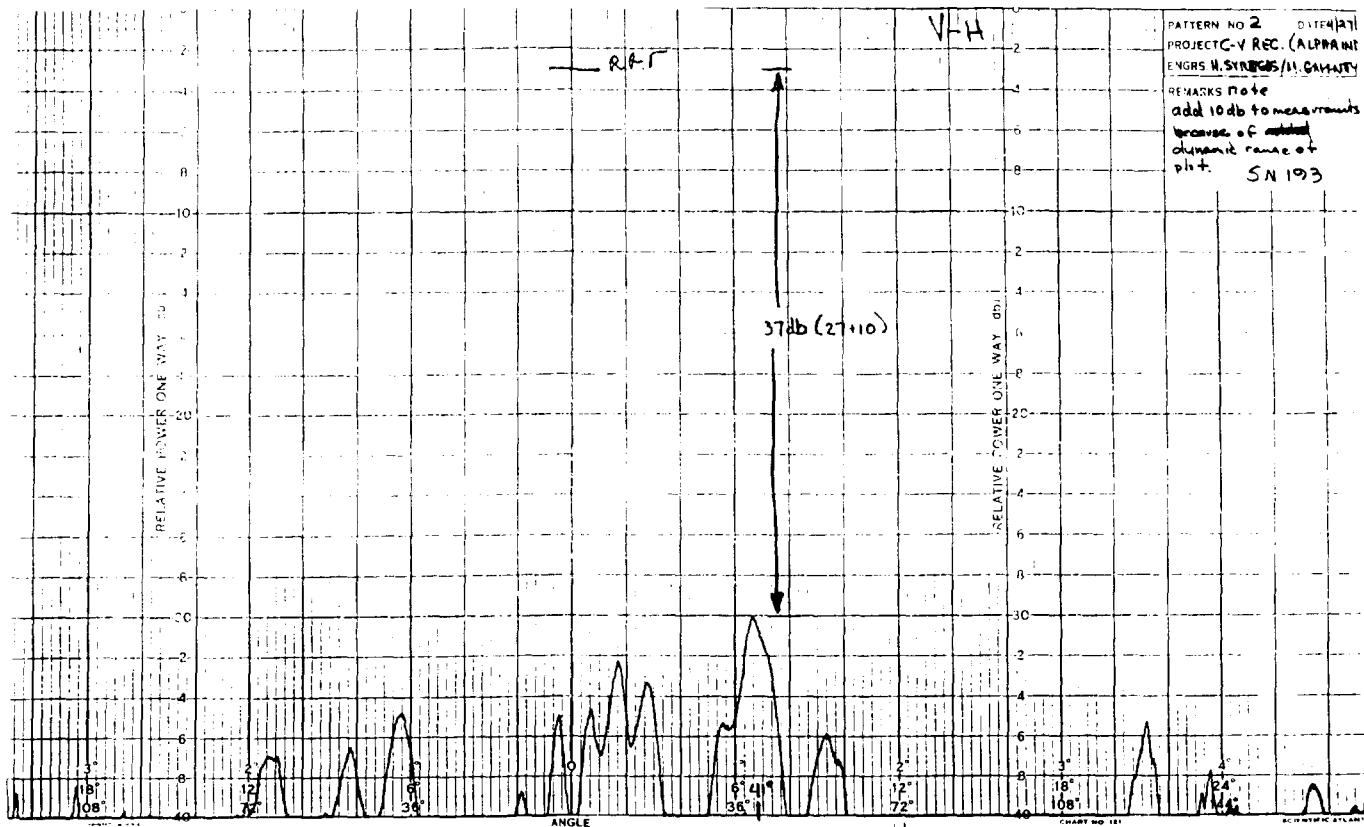


FIGURE B  
RECEIVER ANTENNA GAIN PATTERNS



**GEOGRAPHIC REGIONS OF SIMILARITY IN RAINFALL STATISTICS**  
**(From Crane and CCIR)**

FIGURE C

